Biodiversity Survey Report
Remote Camera Trapping
Terra Grata 2017
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Cover photograph: Malleefowl (*Leipoa ocellata*) recorded on remote camera 6, dated 28/05/2017 at Terra Grata in revegetated habitat.

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1 Executive Summary

This biodiversity camera trapping survey was commissioned by Carbon Neutral Charitable Fund and conducted during the months of April, May and June 2017 on Terra Grata, a property owned by Carbon Neutral Pty Ltd.

The survey resulted in 3112 images being taken over 48 days, capturing 17 species. Most importantly, the survey confirmed the presence of the threatened malleefowl (*Leipoa ocellata*) on the property, with records of malleefowl in two locations on the property, one in remnant vegetation and one in revegetated habitat.

In addition to malleefowl, 12 other native species and four invasive species were recorded during the survey. Results show that fauna species use remnant as well as revegetated habitat, although most species were recorded more often on cameras placed in remnant vegetation.

In order to protect existing malleefowl populations and their habitat, and to ensure that revegetated areas provide quality future habitat, it is recommended that threats, such as pigs and foxes are managed appropriately. Furthermore, it is advisable to ensure sufficient food plants for malleefowl are present in the revegetated areas, in addition to the currently planted species.

Development of a regular monitoring regime using motion-sensing cameras is recommended to provide continuous data on malleefowl and other native species as well as status of feral animals on Terra Grata. This will greatly assist in assessing the effectiveness of feral animal control measures and population trends of malleefowl and other fauna. The management of threats to malleefowl and their habitat is critical to ensure their long-term existence on Terra Grata.
2 Introduction

This survey was conducted to assess the status of medium to large fauna assemblages on Terra Grata. Prior to this survey, information on which species occur on the property and in particular which species are using the revegetated areas was limited and circumstantial. Additionally, anecdotal sightings of malleefowl had been reported, however no sightings had been verified.

Consequently the key questions driving this survey were:

A. Which medium to large fauna species are present on Terra Grata?
B. Which species are present in the revegetated compared to remnant habitat?
C. Are malleefowl present on the property?

The information gathered to address these questions provides an important biodiversity baseline for the property. The results can be used to develop focused conservation and management actions.

With recent advances in camera trapping technologies, it is a popular and effective approach to monitoring wildlife. Camera trapping is particularly suitable because it is relatively in-obtrusive, has low observer error, is comparable across sites and images provide enough detail to identify most species (Fleming et al., 2014). In addition, resulting photographs are an engaging medium and suitable for raising public awareness for conservation.

3 Methods

3.1 Study area

Terra Grata is located in the northern Wheatbelt of Western Australia, approximately 120 kilometres south - east of Geraldton. The property is situated in the northern section of the Avon Wheatbelt IBRA bioregion. This region lies within the globally recognised south - west Australian biodiversity hotspot (Department of the Environment and Energy, 2017). More than 90% of the native vegetation in the region has been cleared for cropping and grazing (Figure 1), causing severe fragmentation of remnant vegetation and habitat loss for many native flora and fauna species (Prober & Smith, 2009).
The climate is semi-arid, with a mean annual rainfall of 353 mm, which falls predominantly during the winter months (Bureau of Meteorology, 2017). The property is approximately 16 square kilometres in size, with most of the native vegetation cleared for cropping and grazing during the 20th century.

Previous surveys indicate that the historical vegetation types would have comprised of acacia and York gum woodlands (Beard, 1975) (Figure 2).
Figure 2. Historic vegetation communities mapped by Beard in 1975. The blue shaded area is classified as ‘Woodland / Scrub’ and the green shaded area as ‘York gum (Eucalyptus loxophleba) and salmon gum (E. salmonophloia) woodland’.

Most of the York gum woodland communities on Terra Grata were cleared, therefore the remaining vegetation is largely consistent of melaleuca and acacia species scrub (Figure 3). In 2010, Carbon Neutral Pty Ltd revegetated 800 hectares of the cleared areas, by direct seeding and hand planting a mix of 20 native species, with York gum (Eucalyptus loxophleba ssp. supralaevis) as the main overstorey species.

Figure 3. Images showing York gums in revegetated areas (left) and remnant melaleuca scrub (right).
3.2 Camera trap deployment

Ten Reconyx™ HC 600 and one Reconyx™ XR6 cameras were deployed in remnant and restored vegetation.

Cameras had 16-GB memory cards and were deployed for 42 days at each site during April, May and June 2017. Cameras operated 24 hours / day and were set to take three photographs at 1 – second intervals when movement was detected to increase the chance of getting an identifiable image of any animal that triggered a camera. The Reconyx™ XR6 camera recorded one image and one video when movement was detected. All cameras were attached to trees at approximately 30 cm off the ground. Where suitable and accessible remnant vegetation was available, cameras were paired, so that one camera was set up in remnant vegetation and another in the adjacent revegetated area (Figure 5).
Figure 5. Google Earth image of camera trap locations on Terra Grata. Dark green symbols indicate cameras in remnant vegetation and light green symbols cameras in revegetated habitat. The blue line indicates the property boundary.
3.3 Fauna activity patterns

The time of day was divided into the following six periods: dawn (half hour before and after sunrise), morning (dawn to noon), afternoon (noon to dusk), dusk (half hour before and after sunset), early night (dusk to midnight) and late night (midnight to dawn) (Story et al., 2014). The number of camera triggers per hour was then calculated for each species during each period.

3.4 Data analysis

All image data were downloaded and electronically processed using the program MapView Advanced™ (Reconyx, 2015). Images were sorted into visits to a camera by an animal. A visit was defined as a single pass or a near continuous movement in front of the camera where the animal is not out of the frame for more than one minute. All images were identified to species level where possible. Some images were of insufficient quality to allow species identification and were therefore excluded from analysis. Images of common wallaroos and western grey kangaroos were grouped into one kangaroo category.
(Macropus sp.), because depending on image quality, no differentiation could be made between those two species.

After sorting and classification, the data was exported to Microsoft Excel (Microsoft, 2010) for further analysis.

Mean days to detection for each species were calculated by counting the days until a species was detected at each camera. Species visits were rationalised to a detection rate per 100 trap days. Visits were also rationalised per camera location and habitat type to explore habitat preferences of each species.

4 Results

4.1 Camera trap performance

Camera traps were checked after 30 days of deployment. No camera traps had full memory cards and each camera showed at least 70% remaining battery power. Image capture rate was variable between locations, possibly due to variability in habitat and associated fauna densities.

4.2 Images

The camera trapping effort of 528 trap days (11 cameras x 48 calendar days), between 18/04/2017 and 11/06/2017 resulted in 3112 photographs (Table 1). Of those, 2442 photographs recorded animals, with 334 individual visits of various fauna species. Photographs taken during set up, false triggers or images where the animal could not be identified were not included in the analysis. Many individuals were photographed several times when moving in front of the camera.

The Reconyx™ XR6 camera recorded 180 photos and videos. Only the images were included in the analysis.
Table 1. Summary of images and fauna visits for all 11 cameras.

<table>
<thead>
<tr>
<th>Camera No</th>
<th>Habitat</th>
<th>Images</th>
<th>Fauna visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>revegetation</td>
<td>48</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>revegetation</td>
<td>75</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>remnant</td>
<td>216</td>
<td>39</td>
</tr>
<tr>
<td>4</td>
<td>revegetation</td>
<td>176</td>
<td>19</td>
</tr>
<tr>
<td>5</td>
<td>remnant</td>
<td>550</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>revegetation</td>
<td>188</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>revegetation</td>
<td>163</td>
<td>17</td>
</tr>
<tr>
<td>8</td>
<td>remnant</td>
<td>456</td>
<td>42</td>
</tr>
<tr>
<td>9</td>
<td>remnant</td>
<td>177</td>
<td>32</td>
</tr>
<tr>
<td>10</td>
<td>revegetation</td>
<td>213</td>
<td>18</td>
</tr>
<tr>
<td>11</td>
<td>remnant</td>
<td>180</td>
<td>50</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td>2442</td>
<td>334</td>
</tr>
</tbody>
</table>

4.3 Species detection

A total of 17 species were recorded in 528 trap days. Of those 17 species, 13 are native and four are introduced (Table 3). All recorded native species are common to the area and of no conservation concern, except for the malleefowl (*Leipoa ocellata*), which is listed as vulnerable under the International Union for Conservation of Nature (IUCN) (BirdLife International, 2016) and the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) guidelines, and threatened in Western Australia (Department of the Environment, 2017). To assist the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) with management, protection and recovery of threatened fauna, malleefowl records have been submitted to the DBCA fauna team (Appendix 1).

Kangaroos (common wallaroos and western grey kangaroos) were the most frequently recorded species, totalling 135 visits, followed by feral pigs (65 visits) and red foxes (47 visits). The average to detect a species ranged from as low as 13 days for kangaroos to up to 23 days for emus and rabbits. Feral cats and an echidna were only recorded on one camera. In contrast, red foxes were detected on 91% of all cameras, followed by feral pigs (82%) and
kangaroos at 73%. Malleefowl were recorded on two cameras, totalling 8 visits and equating to a detection rate of 1.5 per 100 trap days, with an average of 14 days to detection.

Table 2. Detected species, total visits and detection indices across all 11 camera trapping sites.

<table>
<thead>
<tr>
<th>Species</th>
<th>Total visits</th>
<th>Mean days to detection (SE)</th>
<th>Detection rate per 100 trap days</th>
<th>Detection rate per camera location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds (other)</td>
<td>27</td>
<td>17 (3)</td>
<td>5.1%</td>
<td>45.5%</td>
</tr>
<tr>
<td>Echidna</td>
<td>1</td>
<td>42 (NA)*</td>
<td>0.2%</td>
<td>9.1%</td>
</tr>
<tr>
<td>Emu</td>
<td>45</td>
<td>23 (5)</td>
<td>8.5%</td>
<td>54.5%</td>
</tr>
<tr>
<td>European rabbit</td>
<td>3</td>
<td>23 (0.2)</td>
<td>0.6%</td>
<td>18.2%</td>
</tr>
<tr>
<td>Feral cat</td>
<td>3</td>
<td>12 (NA)*</td>
<td>0.6%</td>
<td>9.1%</td>
</tr>
<tr>
<td>Feral pig</td>
<td>65</td>
<td>16 (3)</td>
<td>12.3%</td>
<td>81.8%</td>
</tr>
<tr>
<td>Macropus sp.</td>
<td>135</td>
<td>13 (3)</td>
<td>25.6%</td>
<td>72.7%</td>
</tr>
<tr>
<td>Malleefowl</td>
<td>8</td>
<td>14 (1)</td>
<td>1.5%</td>
<td>18.2%</td>
</tr>
<tr>
<td>Red fox</td>
<td>47</td>
<td>18 (4)</td>
<td>8.9%</td>
<td>90.9%</td>
</tr>
</tbody>
</table>

* Standard Error (SE) could not be calculated as species were only detected at one camera trapping site.

Figure 7. Images of invasive species: 1. Red fox, 2. European rabbit, 3. Feral pig, 4. Feral cat.
<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>Common Name</th>
<th>IUCN status</th>
<th>EPBC status</th>
<th>WA status</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pachycepalidae</td>
<td><em>Colluricincla harmonica</em></td>
<td>Grey shrike-thrush</td>
<td>least concern</td>
<td></td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Artamidae</td>
<td><em>Cracticus nigrogularis</em></td>
<td>Pied butcherbird</td>
<td>least concern</td>
<td></td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Artamidae</td>
<td><em>Cracticus tibicen</em></td>
<td>Magpie</td>
<td>least concern</td>
<td></td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Dromaiidae</td>
<td><em>Dromaius novaehollandiae</em></td>
<td>Emu</td>
<td>least concern</td>
<td></td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Monarchidae</td>
<td><em>Grallina cyanoleuca</em></td>
<td>Magpie-lark</td>
<td>least concern</td>
<td></td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Megapodiidae</td>
<td><em>Leipoa ocellata</em></td>
<td>Malleefowl</td>
<td>vulnerable</td>
<td>vulnerable</td>
<td>threatened</td>
<td>native</td>
</tr>
<tr>
<td>Oreoicidae</td>
<td><em>Oreoica gutturalis</em></td>
<td>Crested bellbird</td>
<td>least concern</td>
<td></td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Petroicidae</td>
<td><em>Petroica goodenovii</em></td>
<td>Red-capped robin</td>
<td>least concern</td>
<td></td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Columbidae</td>
<td><em>Phaps chalcoptera</em></td>
<td>Common bronzewing</td>
<td>least concern</td>
<td></td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Macropodidae</td>
<td><em>Macropus fuliginosus</em></td>
<td>Western grey kangaroo</td>
<td>least concern</td>
<td></td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Macropodidae</td>
<td><em>Macropus robustus</em></td>
<td>Common wallaroo</td>
<td>least concern</td>
<td></td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Tachyglossidae</td>
<td><em>Tachyglossus aculeatus</em></td>
<td>Echidna</td>
<td>least concern</td>
<td></td>
<td>native</td>
<td></td>
</tr>
<tr>
<td>Felidae</td>
<td><em>Felis catus</em></td>
<td>Feral cat</td>
<td>not assessed</td>
<td>key threatening process</td>
<td>introduced</td>
<td></td>
</tr>
<tr>
<td>Leporidae</td>
<td><em>Oryctolagus cuniculus</em></td>
<td>European rabbit</td>
<td>near threatened*</td>
<td>key threatening process</td>
<td>declared pest</td>
<td>introduced</td>
</tr>
<tr>
<td>Suidae</td>
<td><em>Sus scrofa</em></td>
<td>Feral pig</td>
<td>least concern</td>
<td>key threatening process</td>
<td>declared pest</td>
<td>introduced</td>
</tr>
<tr>
<td>Canidae</td>
<td><em>Vulpes vulpes</em></td>
<td>Red fox</td>
<td>least concern</td>
<td>key threatening process</td>
<td>declared pest</td>
<td>introduced</td>
</tr>
</tbody>
</table>

* Assessment relates to its native habitat in Europe
4.4 Comparison between remnant and revegetated habitats

All species, except cats and echidnas were recorded in remnant as well as revegetated habitats (Table 4, Figure 9). Foxes, kangaroos and feral pigs were recorded in most locations, whereas malleefowl, rabbits, cats and echidnas were recorded in only two locations, suggesting that those species are either present in low numbers, or not using areas at which cameras were placed.

Table 4. Comparison of species visits and detection in remnant and revegetated habitats.

<table>
<thead>
<tr>
<th>Species</th>
<th>Total visits Remnant habitat</th>
<th>Mean days to detection (SE)</th>
<th>Detection rate /100 trap days</th>
<th>Detection rate /camera location (n = 5)</th>
<th>Total visits Revegetated habitat</th>
<th>Mean days to detection (SE)</th>
<th>Detection rate /100 trap days</th>
<th>Detection rate /camera location (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds (other)</td>
<td>9</td>
<td>19 (6)</td>
<td>4%</td>
<td>40%</td>
<td>18</td>
<td>15 (5)</td>
<td>6%</td>
<td>50%</td>
</tr>
<tr>
<td>Echidna</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>1</td>
<td>42</td>
<td>0.3%</td>
<td>17%</td>
</tr>
<tr>
<td>Emu</td>
<td>34</td>
<td>17 (6)</td>
<td>14%</td>
<td>60%</td>
<td>11</td>
<td>28 (7)</td>
<td>4%</td>
<td>50%</td>
</tr>
<tr>
<td>European rabbit</td>
<td>2</td>
<td>22</td>
<td>1%</td>
<td>20%</td>
<td>1</td>
<td>23</td>
<td>0.3%</td>
<td>17%</td>
</tr>
<tr>
<td>Feral cat</td>
<td>3</td>
<td>12</td>
<td>1%</td>
<td>20%</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Feral pig</td>
<td>51</td>
<td>14 (2)</td>
<td>21%</td>
<td>100%</td>
<td>14</td>
<td>19 (6)</td>
<td>5%</td>
<td>67%</td>
</tr>
<tr>
<td>Macropus sp.</td>
<td>117</td>
<td>8 (1)</td>
<td>49%</td>
<td>80%</td>
<td>18</td>
<td>19 (5)</td>
<td>6%</td>
<td>67%</td>
</tr>
<tr>
<td>Malleefowl</td>
<td>5</td>
<td>11</td>
<td>2%</td>
<td>20%</td>
<td>3</td>
<td>16</td>
<td>1%</td>
<td>17%</td>
</tr>
<tr>
<td>Red fox</td>
<td>32</td>
<td>15 (6)</td>
<td>13%</td>
<td>100%</td>
<td>15</td>
<td>21 (5)</td>
<td>5%</td>
<td>83%</td>
</tr>
</tbody>
</table>

All species, except birds were recorded more often in remnant habitat than revegetated areas, averaging a 13% higher detection rate per camera location. In particular the likelihood to detect feral pigs and red foxes was 33% and 17% higher respectively in the remnant vegetation. Malleefowl and emus only showed a 3% increased detection rate for remnant habitat compared to revegetated areas, suggesting that they may use both habitats equally. It should be noted that malleefowl were only recorded on one camera in each habitat, therefore habitat preference is difficult to determine.
4.5 Activity patterns

Activity patterns of all species was variable, with kangaroos being most active during dawn and dusk, emus and other birds during the hours of dawn, morning and afternoon, and pigs and foxes predominantly during the night and dawn. In contrast, malleefowl were only recorded during the afternoon and dusk (Figure 10). European rabbit, feral cat and echidna images were omitted from the analysis due to the low number of records.
Figure 10. Daily activity patterns for six commonly recorded fauna species.

Figure 11. Images of 6 species recorded during their peak activity times.
5 Discussion & Recommendations

5.1 Malleefowl (*Leipoa ocellata*)

The malleefowl is a listed species in all Australian states under IUCN red list criteria (Table 3). Its population has declined greatly over the last 100 years and it has experienced severe decline in its former range (Figure 12), due to loss and fragmentation of native vegetation and predation by feral animals (Benshemesh, 2007). Malleefowl are a charismatic ground-dwelling bird, weighing up to 2.5 kilograms.

![Figure 1. Current and historical range of Malleefowl across Australia](image)

Figure 12. Current and former malleefowl distribution across Australia (National Malleefowl Recovery Team, 2017).

To nest they create mounds of soil and leaf-litter, ranging between 5 m in diameter and 1 m height (Figure 13). These nests are kept at a stable temperature for egg incubation by adding and removing leaf litter (Frith, 1961). According to previous studies, malleefowl are active during the day and roost on trees at night (National Malleefowl Recovery Team, 2017).
Most time of the year is spent on construction and maintenance of their nests. During the months of April to June (the time period this survey was conducted), malleefowl start to renovate existing mounds for nesting (Booth, 1985).

![Malleefowl mound on Eurardy Reserve, Western Australia.](image)

Figure 13. Malleefowl mound on Eurardy Reserve, Western Australia.

Malleefowl are predominantly found in semi-arid to arid areas, usually in acacia/mallee shrublands or low woodlands. They prefer areas with sandy soils and an abundance of leaf litter for mound building. Areas with higher rainfall and more fertile soils support denser populations of birds due to more abundant food plants and thicker habitat. Malleefowl feed on plant material such as seeds, fruits and flowers of herbs and shrubs and invertebrates. They forage on the ground and from vegetation up to 60 cm high (Frith, 1961).

The national Malleefowl Recovery Plan (Benshemesh, 2007) lists the following seven key threats to malleefowl populations:

1. Clearing
2. Fragmentation and isolation
3. Livestock grazing
4. Predation
5. Fire
6. Disease, inbreeding and chemical exposure
7. Climate change

Many of those were already recognised by Firth in 1961.
5.2 Malleefowl habitat restoration

This survey confirmed the occurrence of malleefowl on Terra Grata in both remnant and revegetated areas (Figure 14).

![Google Earth image showing locations of malleefowl records](image)

Figure 14. Google Earth image showing locations of malleefowl records (camera 3 in remnant and camera 6 in revegetated habitat).

It is unclear if malleefowl use the revegetated areas for nesting and/or foraging, however, previous research has shown that it takes up to 30 years before malleefowl will build mounds in previously burned habitat (Benshemesh, 2007). It is therefore likely that
relatively young revegetated areas are used for foraging only. No research has been conducted to date to test if, and after how many years, malleefowl will nest in restored and revegetated habitats. Several revegetation projects aimed at restoring malleefowl habitat have been set up in the Midwest of Western Australia in the last two years (Greening Australia, 2017), however research is needed to understand how long it takes for malleefowl to use the revegetated areas as breeding and/or foraging habitat.

To restore malleefowl habitat and to create links between existing patches, trees and shrubs should be planted to provide crown and horizontal cover. The shrub layer is most important as it provides the majority of food resources for malleefowl (Frith, 1961). Plantings therefore need to include a rich shrub layer, such as leguminous shrubs and herbs (i.e. acacias, cassias, Pittosporum sp., Beyeria sp.). In addition, habitat can be protected by fencing areas to exclude livestock (Benshemesh, 2007).

Figure 15. Malleefowl recorded on camera 6 in revegetated habitat.
5.3 Threat management

5.3.1 Feral pig

Feral pigs cause considerable damage to agriculture and native flora and fauna, costing the Australian economy more than $100 million annually (PestSmart, 2011a). Feral pigs were introduced by early European settlers, and are now widespread across Australia. Their diet predominantly consists of plant material, but they will also feed on invertebrates, and other fauna such as birds, reptiles and mammals. In addition to damage caused by feeding, pigs impact on the environment by rooting, trampling and spreading diseases and parasites (Department of Primary Industries and Regional Development, 2016). Furthermore, feral pigs damage fences, water courses, cause soil erosion and reduce water quality.

5.3.2 Feral pig control

Feral pigs are listed as a ‘Declared Pest’ in Western Australia and should be controlled (Department of Primary Industries and Regional Development, 2016a). The responsibility of feral pig control lies with the landholder. ‘Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs’ is also listed as a ‘key threatening process’ under the EPBC Act (Department of Environment and Energy, 2015).
Feral pigs were recorded in high numbers on Terra Grata, with up to 13 pigs visible in one image sequence.

![Feral pigs recorded on camera 6 in remnant melaleuca scrub.](image)

Figure 17. Feral pigs recorded on camera 6 in remnant melaleuca scrub.

Considerable feral pig damage to soil and plants was visible on the property as shown on images below. It is therefore recommended that feral pigs are controlled at the property to reduce further threats to native fauna and flora and adjacent agriculture. Pigs can be controlled using a variety of methods. 1080 baiting, shooting and trapping are commonly used to remove feral pigs. It should be noted that no single method will completely remove feral pigs from any given area, therefore a combination of methods is needed.
The Department of Biodiversity, Conservation and Attractions (DBCA) runs an annual pig baiting program in the Geraldton district. In line with DBCA procedures, baiting is recommended in summer (January to April), when less green vegetation is available and bait up-take is higher. Bait stations are set up in high use areas, with a mix of molasses and flaked lupins in a line on the ground or in multiple piles, initially for pre-feeding only. Several piles are needed to avoid large bores to dominate a pile. Depending on feral pig abundance, sites need to be checked every few days and topped up with flaked lupins. To assist with monitoring of bait take-up, remote monitoring cameras should be deployed. After approximately one week of pre-feeding liquid 1080 poison is mixed with the flaked lupins. Bait stations are to be monitored to check if animals still come to feed and if more bait is needed (J. Sercombe, pers. comm., 2017). For more details on feral pig control refer to the PestSmart fact sheet ‘Practical feral pig control’ in Appendix 2 (PestSmart, 2011b).
5.3.3  Red fox

Red foxes are native to Europe, Asia, North America and northern parts of Africa. The first British settlers introduced foxes to Australia for hunting with foxhounds from 1845 onwards. Since then, foxes have spread across the continent and are now found in all regions except northern Australia (Department of Sustainability, Environment, Water, Population and Communities, 2010).

Red foxes have significant environmental and agricultural impacts, costing an estimated $207.5 million annually (Department of Agriculture Victoria, 2017). Predation by red foxes causes severe damage to wildlife populations, in particular mammals in the critical weight range of 35 to 5500 g, and ground dwelling birds and reptiles (Department of Sustainability, Environment, Water, Population and Communities, 2010). Along with habitat degradation, predation by red foxes has contributed to the extinction of 54 vertebrate species, including 20 mammal species (Johnson, 2006).

Red foxes occur in most habitats, and are found in greater numbers in human-dominated areas. They are predominantly carnivorous, but also scavenge on a range of resources including carrion, human refuse and plant material. If present, rabbits form a large part of their diet, including other small to medium sized mammals, birds and reptiles (Department of Agriculture Victoria, 2017).
Figure 19. European red fox distribution (Image source PestSmart 2011c)
5.3.4 Red fox control

The red fox is listed as a ‘Declared Pest’ in Western Australia and should be controlled (Department of Primary Industries and Regional Development, 2017). The responsibility of fox control lies with the landholder. ‘Predation by foxes’ is also listed as a ‘key threatening process’ under the EPBC Act (Department of Environment and Energy, 2011).

Populations of red foxes in rural areas can be controlled using a range of methods such as 1080 baiting, shooting and den fumigation and ripping. However, baiting is the most cost effective and efficient method of achieving long-term fox control, reducing numbers by more than 65% (Department of the Environment, Water, Heritage and the Arts, 2008). Baiting can occur all year round, however is most successful during late winter and spring when foxes are less mobile (Department of Primary Industries and Regional Development, 2016b).

For more details on fox control, follow the Department of Primary Industries and Regional development’s guidelines (2016c) for fox 1080 baiting and the PestSmart ‘baiting for fox control’ factsheet in Appendix 3 (PestSmart, 2013).
5.3.5 Other threats

It should be noted that feral cats and rabbits could also pose threats to malleefowl. Feral cats may prey on young malleefowl hatchlings and potentially adult birds, and rabbits compete for resources and degrade habitat. Both species were recorded in low numbers on Terra Grata. Low detection of these species could mean that only few individuals are present, however it is also possible that the applied method was insufficient to detect these species. To ensure accurate detection levels, complimentary methods such as spotlighting or track transects could be implemented as a monitoring strategy. If this or subsequent camera monitoring shows that numbers of cats and rabbits increase, options of control should be investigated.

6 Conclusions

Survey results provided insights about the presence of medium to large fauna species on Terra Grata. It is encouraging to see that native species are using revegetated habitat, in particularly the threatened malleefowl. However, camera images also revealed a number of invasive species posing threats to native fauna and flora.

To minimise threats and improve habitat conditions for malleefowl and other native fauna and flora on Terra Grata, a regular feral pig and red fox control program should be implemented. To assess its effectiveness, regular annual camera trapping monitoring is recommended. Malleefowl will also benefit from planting of additional food plants and keeping the property free of livestock grazing.
7 References


# Appendices

## 8.1 Appendix 1

### Malleefowl Report Form

**ANIMAL NAME:** Malleefowl (Leipoa ocellata)  
**NUMBER SEEN:** see attached records

**OBSERVATION DATE:** April, May, June 2017  
**TIME:**

**EMAIL:** t.schroeder@murdoch.edu.au  
**PHONE:** 0458 172 925

**ADDRESS:** PMB 65 Eurardy Reserve, Geraldton 6530

**OBSERVATION LOCATION** (Coordinates - latitude and longitude, property address, distance to nearest intersection, etc.)

Terra Grata, near Canna WA, see attached for coordinates

<table>
<thead>
<tr>
<th>CERTAINTY OF ANIMAL IDENTIFICATION:</th>
<th>DESCRIPTION OF MALLEEFOWL (include comparisons e.g. similar size to chicken, number of adults and juveniles etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not sure</td>
<td>Adult</td>
</tr>
<tr>
<td>Moderately certain</td>
<td></td>
</tr>
<tr>
<td>Certain</td>
<td></td>
</tr>
<tr>
<td>Photo</td>
<td></td>
</tr>
</tbody>
</table>

**OBSERVATION TYPE:** (Select as many as applicable)

- Live
  - Day sighting
  - Night sighting
  - Remote camera
  - Trapped
  - Spotlighting

- Dead
  - Roadkill
  - Found shot
  - Found poisoned
  - Killed by another animal
  - Unknown cause of death

- Secondary signs
  - Mound
  - Egg or shell
  - Feathers
  - Heards
  - Tracks
  - Bones

**OBSERVATION DETAILS** (What was the malleefowl doing? Mound description, habitat type, associated flora species etc.)

Moving past camera trap, habitats included remnant acacia shrub and revegetated areas (York gum, acacia species mix)

**OTHER COMMENTS** (Include details of additional data available and how to locate it, land tenure and use, fire history etc.)

Terra Grata is owned by Carbon Neutral Pty Ltd, PO Box 18, Cottesloe, Western AUSTRALIA 6911

**ATTACHED:** Map ☐ Mudmap ☐ GIS data ☐ Photo ☐ Field notes ☐ Other: Details of individual of records

**COPY SENT TO:** Regional Office ☐ District Office ☐ Other: ☐

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**Please return form to:** 
fauna@dpaw.wa.gov.au

or Species and Communities Branch, Department of Parks and Wildlife, Locked Bag 104, Bentley Delivery Centre WA 6983

Record entered by: __________________________  Date entered: ______________  Database no: ____________
8.2 Appendix 2

Poisoning: Ground-based poison baiting is one of the most economical and effective ways to control feral pigs on a broad scale. Ground baiting can achieve around 70-99% rapid population knockdown across a range of Australian habitats. Aerial baiting is also used in some regions of Australia but is typically less effective than ground baiting because feral pigs generally need to become familiar with taking bait first. Despite this, in dry times aerial baiting can be very effective. During an exotic disease outbreak, aerial baiting would be an invaluable tool for rapid and widespread eradications in quarantined and remote areas. Poison baiting is generally not done in tropical rainforests (about 2% of the total feral pig range) due to abundant non-target species and ready food supply — mainly fruit.

Toxicants: In Queensland, New South Wales, Victoria and Western Australia, the odourless and tasteless compound 1080 (sodium fluoroacetate) is routinely used to poison feral pigs. Yellow phosphorous (commercial names: CSSP, SAP) is registered for feral pig control in some Australian states and territories, but because of animal welfare concerns surrounding its use, it is being phased out. Warfarin and cyanide are available for experimental purposes, but both are unsuitable for feral pig control due to issues with humaneness, and taste and delivery respectively. The fast-acting and more humane poison sodium nitrite, a common human food preservative, is highly lethal to pigs and currently undergoing registration in Australia. This new toxicant, which must be specifically formulated, is expected to be available from 2013.

Feral pigs feeding at a ‘cluster’ bait station. Glenrock Station, NSW. Image: Invasive Animals CRC
Poisoning process: Ground baiting is a multistep process. First, unpoisoned food materials such as grain, fruit or manufactured baits (PIGOUT® free-feed) are offered for about 3-10 days every few hundred meters along a trail or at a bait station near recent feral pig activity. This free-feeding step, although taxing time and effort, is essential for attracting the local feral pig population and increasing bait consumption. Once baits are taken, feral pigs are slowly drawn into “cluster bait” stations by retreating bait trails to nearby feeding hot spots. This ensures that toxic baits can then be presented across the smallest possible area.

Toxic baits are introduced to cluster bait stations once free-feed bait uptake levels off, and this is continued until toxic bait uptake ceases (1-3 nights). Feral pigs are often killed within the first few nights of the lethal baiting phase. Follow-up monitoring determines if pigs remain in the area and whether further baiting is needed. There are usually strict protocols for accessing, making and deploying feral pig poisoned baits, and accreditation may be required. Operators should ensure they are familiar with relevant and current state or territory legislation.

Depending on the toxicant used, the drawbacks of baiting include animal welfare concerns, development of bait shyness and the risk of primary and secondary poisoning of non-target species. However, careful selection of bait material, and technologies such as new toxins and bait delivery devices that target feral pigs ( Hogropper™ ) address some of these concerns. Poison baiting is often used in early stages of pig management, as it is the least invasive technique causing minimal disturbance of the population. The more direct techniques such as trapping and shooting can be used as follow-up activities. The best time to bait is when habitat food is least abundant – usually summer in southern Australia and at the end of the dry season (around November) in northern Australia.

Trapping: Trapping is a valuable method for managing feral pigs at relatively low densities and where control by poisoning or shooting is not feasible, such as near urban areas. In the wet tropics of Australia, where non-target wildlife species are abundant, trapping is considered the most effective technique for reducing feral pig numbers. Well-designed traps can be pig specific and captured pigs may be used as a commercial resource. Trapping efficiency can range from 28-83% knockdown of a feral pig population.

Trap design and process: Trap design vary considerably. In Australia, the most popular styles used tend to be slin, panel or box traps. All basically consist of an anchored steel mesh enclosure with a lure or bait that the target pig find attractive. Pigs gain access through a one-way entrance and are then unable to escape. Trapped pigs are killed as quickly and humanely as possible by shooting. Capture rates are heavily influenced by season, natural food availability and trap placement within the landscape. As with poison baiting, free-feeding is an essential step in the trapping process and allows a trap to coax greater numbers of pigs into the trap before it is set. Hunting activity in the area usually makes trapping less effective.

Disadvantages with trapping relate to the time and cost of initial trap construction and ongoing maintenance of traps. For animal welfare reasons, traps must also be checked regularly to minimise the time that trapped pigs or non-target species are held. Cost recovery via commercial harvest and combining trap inspections with regular property rounds can help manage these drawbacks. Another disadvantage is that some pigs become “trap shy” and are more difficult to capture. Alternative controls can be used to remove trap-shy individuals.

“Shooting and hunting are widespread, popular techniques for managing feral pigs”

Ground shooting and hunting with dogs: Intensive ground shooting – both recreational and professional – can be effective in some localised settings where pig numbers are low. Hunting with dogs, also referred to as “dogging”, can make ground shooting campaigns more successful, particularly in dense habitat. Dogging may be useful for locating and removing residual pigs after other control.
techniques have reduced population densities\textsuperscript{10}. In general, the effectiveness of ground-based hunting largely depends on the skills of the hunter and training of the dogs. Due to high labour and time costs, and the localised nature of this form of control, ground shooting and hunting are more suited to short-term management campaigns.

Additional considerations are that lost dogs have the potential to become feral themselves and harm wildlife and livestock operations. Studies have shown that dogs can pass close (within 100 metres) to pigs without deterring them and that hunting with dogs may remove less than 20% of the pigs present\textsuperscript{11}. Hunting can also cause temporary dispersion and altered behaviour of feral pigs, such as greater dependence on cover and more nocturnal feeding habits. Because of this, ground shooting and dogging should be used as a secondary method to other more productive forms of control.

**Aerial shooting:** Aerial shooting by helicopter is more effective than ground shooting and considered very competitive with other control methods on a cost-per-hectare basis in the right conditions\textsuperscript{2}. Used in a coordinated fashion, aerial culling programs have the potential for large-scale and rapid knockdown (60-80% efficiency)\textsuperscript{12-13} of feral pig populations in Australia.

This process involves the helicopter being guided by an experienced pilot and spotter to locate and pursue individuals or mobs of feral pigs. On board, an accredited shooter uses a semi-automatic rifle or pump-action shotgun to deliver lethal chest (the preferred target) or head shots to the animals\textsuperscript{14}.

**Aerial shooting** is a visible, high-profile approach to feral pig control. It can potentially draw landholders and pest animal managers together in a unified approach over large areas. But its effectiveness and cost efficiency depend on high pig densities, good flying conditions and mostly open countryside. Aerial shooting that is used in isolation, as a once-a-year control exercise, may only offer short-term and localised reduction of feral pig numbers\textsuperscript{15-16}.

Aerial shooting is a particularly useful option when environmental conditions severely limit access for ground-based controls such as trapping, dogging or poison baiting (e.g. after flooding, in swampy land). The choice of the best time for aerial shooting is a balance between winter, when pigs are more active than usual in daylight, and summer, when pigs concentrate around water points and light cover.

**Judas pig technique:** Ground and aerial shooting may benefit from the use of ‘Judas’ pigs, which are radio-collared individuals re-released to associate and reveal the location of pigs in the area. Judas pigs have been used with mixed success in Australia and the United States, mostly for removing remaining pigs in the last stages of eradication attempts\textsuperscript{17-18}.

Sows make the best Judas pigs, especially those that are socially connected to pigs in the target area. This is a specialised technique however, that requires telemetry equipment and skilled operators and is not effective when pig densities are high. Also, re-released sows have the potential to breed and repopulate an area unless they are desexed (spayed/neutered) first\textsuperscript{19}.

**Fencing:** Exclusion fencing is a physical, non-lethal way of protecting high-value areas from feral pigs, such as lambing paddocks, grain crops or wildlife refuges\textsuperscript{20-21}. Although considered an expensive option and not practicable at a large scale, fencing can be used in a tactical, time-dependent way to restrict feral pig movement.

Fences need to be strong to exclude robust animals like feral pigs. As a result, construction costs can reach about $3500/km for a pig-specific fence\textsuperscript{22}. Electrified strands, as outriggers or staked in front, have been shown to greatly improve the effectiveness and longevity of the fence\textsuperscript{23}. Unfortunately, if feral pigs are already habituated to the food source or area being protected, fences are more likely to be breached. Once breakthrough occurs, a fence becomes ineffective.
Summary: In Australia, the most successful efforts to manage feral pigs and the damage they cause have tended to involve the lethal techniques of poisoning, trapping, shooting and hunting. Other potential forms of control include habitat manipulation, guardian animals, biological control and contraception. For the most part, these latter techniques remain either untested or impractical for feral pig management. Studies have shown that biological and fertility approaches are unlikely to ever be viable options for feral pig control in Australia, due to potential flow-on into the $1 billion domestic pork industry. As such, the more traditional control techniques will remain the best options for the foreseeable future.

Effective control of invasive animals rarely works with a single-strategy approach. The listed feral pig control techniques in this factsheet are best used together in a strategic fashion to manage feral pig populations, and reduce their impact on farms and the environment. The techniques should be appropriately chosen based on environmental conditions, timing, habit and the desired outcome. For further details on how to successfully design and implement feral pig management strategies please refer to the various resources and guides listed at right or visit http://www.feral.org.au.

Further information:

Exclusion fencing, Kangaroo Island, SA. Image: S. Lapidge

Feral Pig Factsheet

December 2011
8.3 Appendix 3

Baiting for fox control

**Introduction:** Poison baiting is currently the most effective broad-scale method of fox control. Toxins used against foxes in Australia must be registered with the Australian Pesticides and Veterinary Medicines Authority (APVMA). Baits can only be obtained through licensed officers or designated government agencies in each state and territory, and there are strict guidelines relating to the use and placement of baits. Some states require specific chemical training to have been completed, so it is advisable to check specific requirements with your local agency.

Ground baiting is the main technique used. This involves burying baits along tracks, fence lines and other areas where foxes are known to travel. In remotes, sparsely populated areas, government agencies are permitted to use aerial application of baits.

**How specific are baits for foxes?** Baits target foxes over other species in three ways:

- through the toxin
- through the bait substrate
- by bait presentation

Foxes are particularly sensitive to 1080 (sodium monofluoracetate), the most commonly used toxin, and the newly developed PAPP (para-aminopropiophenone, not commercially available at time of printing). This allows a low dose rate to be used for these baits, making them more specific for foxes and less harmful to non-target species. Red meat, chicken and commercially developed baits, such as Foxoff® (Animal Control Technologies), De-fox™ (Parks National Pty Ltd) and Pro-bait (Western Australia Department of Environment and Conservation), are sometimes preferred because of their palatability to foxes and relatively high target specificity. The practice of burying baits also helps target foxes: the fox readily digs and consumes buried food items, but few native animals are inclined to excavate and eat buried baits.

**When is the best time to bait?** The most effective time to bait is usually during late winter and spring when fox populations are at their lowest. This is generally just before breeding and is directly followed by a time of high food demand, when the young cubs are being reared. At other times, especially in autumn, foxes are more mobile and tend to re-establish quickly into vacant territories. Baiting may need to be repeated more often at these times to achieve effective results.

**How often should I bait?** Baiting programs have been shown to be most effective when done twice a year. This causes maximum disruption to both the breeding (late winter/spring) and migration (autumn) stages of the fox’s life cycle.

**How should the baiting be done?** For maximum success, baits should be available to foxes for at least ten days. They should be checked at least every two days, and replaced until no more are being taken. Baits should be placed at strategic points along tracks and fence lines where foxes regularly travel, or near carcasses or other attractants, allowing for distance restrictions from residences and boundaries.

Baits should be buried 5–10 cm deep or tethered (in Queensland and Western Australia only), at 200–500 m intervals, with a total of about five baits laid for each square kilometre. The positions of baits should be marked with tape or pegs so they can be easily checked later. Lures and scents can be used to attract the foxes, although continuous scent trails should be avoided.
Is baiting with a group worthwhile? Yes. Group baiting programs, involving cooperation among neighbouring landholders and the community, can both lower the costs of baiting and help reduce the level and speed of fox reinvansion.

How much does a baiting program cost? The cost of a program will vary depending on the size of the property, the number of foxes, and the number of neighbours participating. Costs generally range from $0.40 to $1.00 per hectare. Your local agency should be able to provide advice on the most cost-effective way to bait foxes in your area.

How do I know if the baiting has worked? Dead foxes are seldom found after a baiting program, giving the false impression that the program was not effective. If correct baiting procedures are followed, the number of baits taken can give an indication of the number of foxes killed. Fox population monitoring techniques (e.g. remote sensing cameras, sand pads, spotlight counts) can be used, monitoring changes in the population of prey species (e.g. wildlife, lambs) will give a better indication of the program’s success.

Foxes are known to store their food for later. Will this affect my baiting program? Foxes are known to cache surplus food to secure a meal when food is scarce. This behaviour can have a major effect on the effectiveness of a baiting program by decreasing the number of available baits. This behaviour also increases the poisoning risk to non-target species, since the location of baits becomes unknown after they are moved by foxes. The best way to deal with this problem is to take note of multiple bait taken in one location and, if caching is suspected, stop replacing the baits in that spot.

Are fox baits safe for the environment? Both 1080 and RAPP are considered environmentally safe, as they break down relatively quickly, and are neither mobile nor persistent in the soil.

Does fox baiting pose a risk to native animals? Following best practice baiting methods is important to maximise the effectiveness of any baiting program and minimise the risk posed to non-target animals, regardless of which type of bait is used. Burying the baits helps eliminate the risk to most non-target species, including birds. Baits should not be laid in areas where native predators, such as goannas and quolls, are known to be active. If in doubt, the area should be monitored before baiting, using non-toxic baits and sand pads or remote sensing cameras.

Why do I need to collect uneaten baits at the end of my program? Baits and toxins decay over time so the potential exists for foxes to consume sub-lethal doses. Bait aversion results when a sub-lethal dose of toxin is consumed, making the fox ill instead of killing it. Removing all uneaten baits at the end of a program is important to reduce the risk of bait aversion as well as to prevent poisoning of non-target species.

How can I protect my pets? The best way to protect pets is to make sure they do not have access to areas where baits are stored or laid. Domestic dogs are just as susceptible to baits as foxes, so they need to be restrained both during a baiting program and in the weeks directly following it.

Further information:
- PestSmart Factsheet: Frequently asked questions about RAPP (WOF32, 2013). Invasive Animals CRC.

Invasive Animals Ltd. has taken care to validate the accuracy of the information at the date of publication (June 2013). This information has been prepared with care but it is provided "as is", without warranty of any kind, to the extent permitted by law.